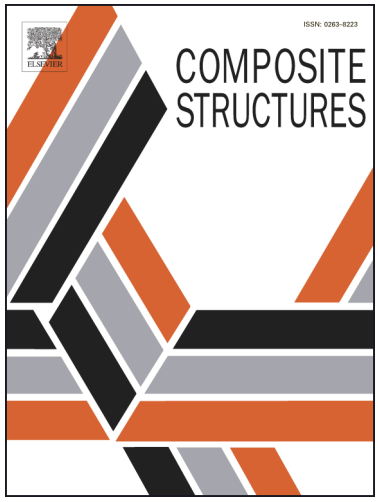


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# Evaluation of the seismic performance of reinforced concrete frames strengthened with CFRP fabric and NSM bars

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**ABSTRACT**

An experimental program was conducted to evaluate the seismic performance of rigid frames strengthened with externally bonded CFRP fabric and near-surface mounted (NSM) CFRP bars. Three rigid frame specimens were subjected to cyclic loading. The three specimens were identical in size and internal reinforcement. One specimen served as control while the other two specimens were strengthened using CFRP fabric and NSM bars such that they have equivalent capacity at first yielding. CFRP wraps were used on the strengthened specimens to anchor the main CFRP sheets and NSM bars and to prevent/delay debonding of the FRP reinforcement. Test results indicated that both techniques delay the yielding of the internal steel reinforcement and result in an increase in the flexural strength of the members, an increase in energy dissipation, and a decrease in stiffness degradation. However, the load-deflection response for both strengthening techniques flattens shortly after yielding of internal steel due to localized debonding of the fabric and the bars, unlike monotonic loading which typically shows post-yielding stiffness. Results also showed that strengthening with CFRP fabric results in fewer cracks, more energy dissipation, and less strength degradation after yielding than strengthening with NSM bars where the latter results in higher ultimate strength.

Keywords: carbon fiber; near-surface mounted technology; seismic strengthening; beam-column joints; cyclic loading; hysteresis

## 1. Introduction

FRP strengthening is a well-matured technology utilized for the rehabilitation of various reinforced concrete systems. There are many contributions in the area of flexural strengthening of reinforced concrete members subjected to monotonic loading [1-12]. However, utilizing this

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